RESEARCH UPDATE:

Assessment of PM and NO_X Retrofits for Diesel Control Program

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Research Division

California Environmental Protection Agency
AIR RESOURCES BOARD

ACKNOWLEDGEMENTS

CARB Investigators

Research Division

Monitoring and Laboratory Division

Mobile Source Control Division

Collaborators

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bp

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San Joaquin RTD

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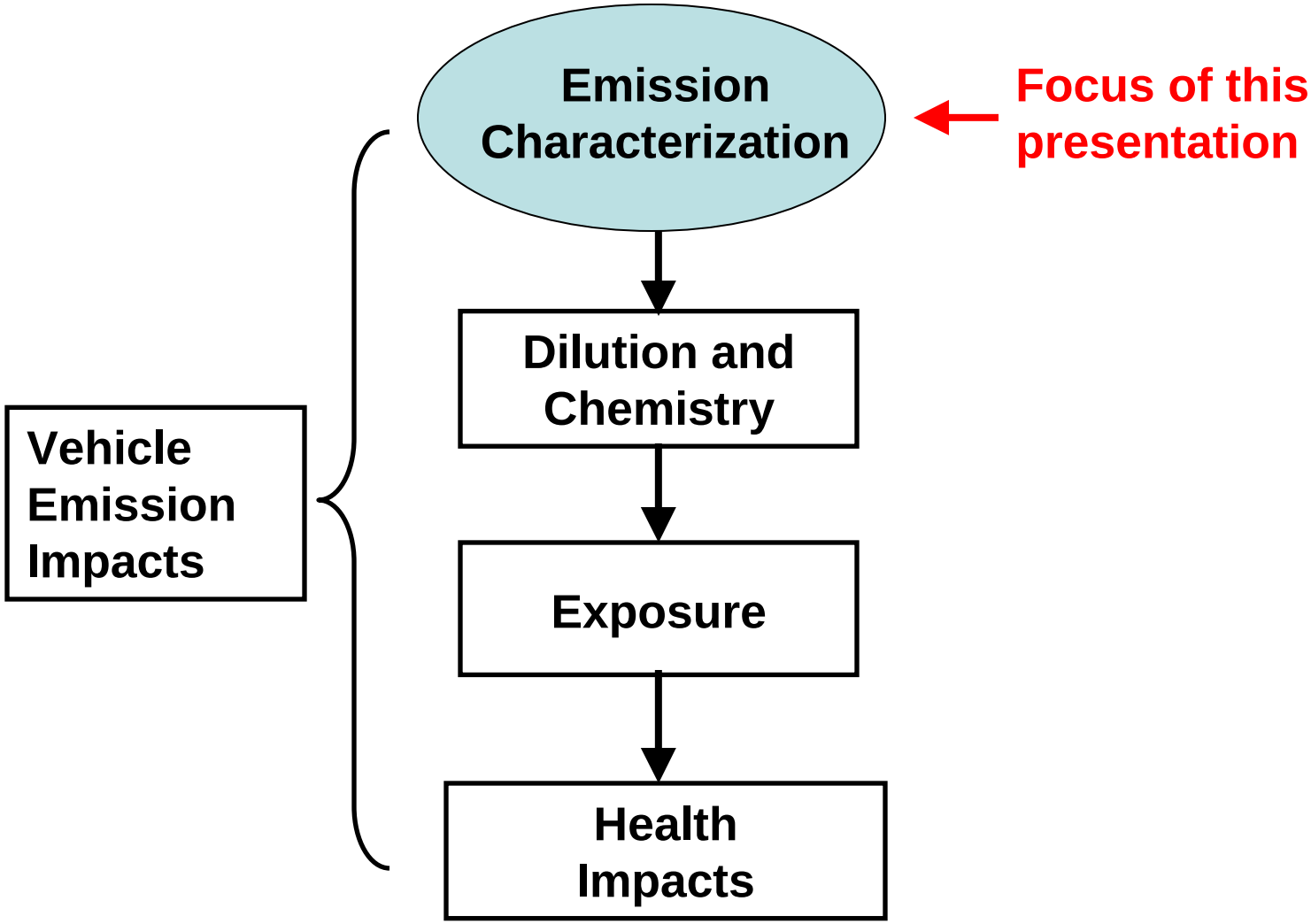
OVERVIEW

- **The Diesel Control Program**
  - Designed to reduce $PM_{2.5}$ and NO_x emissions
- **Retrofits**
  - A key component of the Program
- **Retrofit Goals Being Achieved**
  - Diesel PM and NO_x greatly reduced
  - Also helps reduce ozone and secondary $PM_{2.5}$
  - Significant health benefits
- **For Future Study**
  - Retrofit technologies generate volatile particles in some cases
  - Investigation of new measurement methods
  - Continue health indicator assessments

THE ROLE OF ARB'S EMISSIONS RESEARCH PROGRAM

- **Positions ARB to be proactive on emerging science**
- **Addresses the first step in the link from vehicles to health impacts**
- **Used in combination with other work to inform policy**

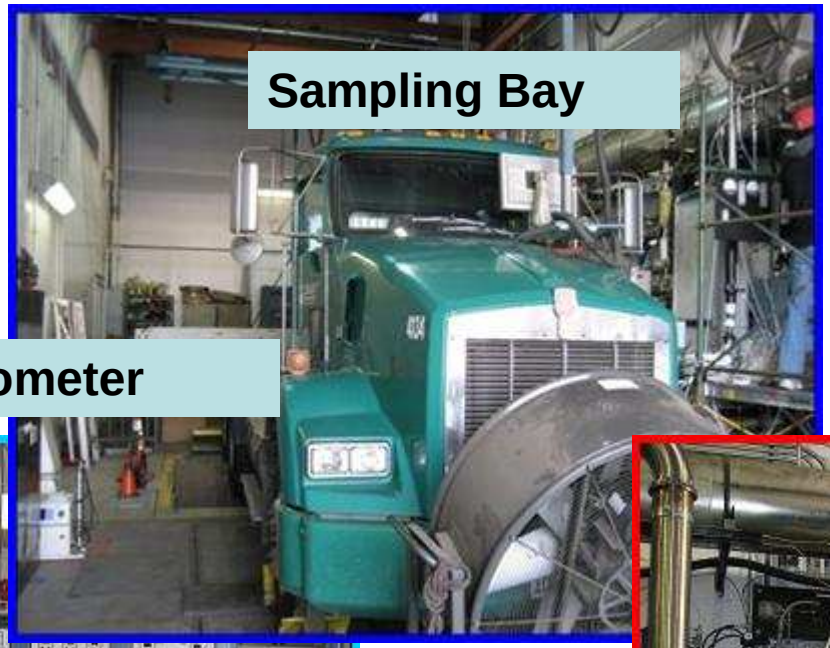
LINKING EMISSIONS AND HEALTH



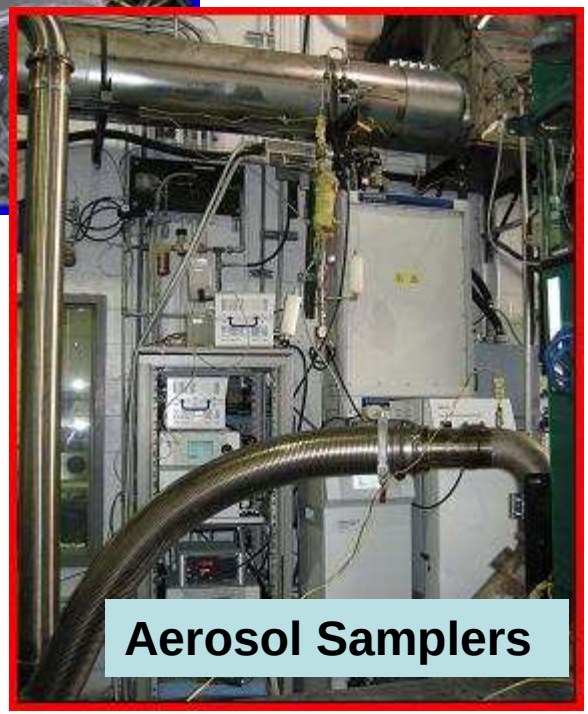
HEAVY DUTY VEHICLE EMISSIONS RESEARCH PROGRAM

- **Began with CNG and Clean Diesel Bus Studies**
- **Current Study: Diesel Retrofits**
  - PM and NO_X
  - Toxicity Indicators
- **Will Continue**
  - 2010 Technology CNG Buses
  - Light Duty Vehicles
  - Alternative Fuels
  - Ultrafine Particle Formation

CARB HEAVY-DUTY VEHICLE EMISSIONS LAB



Chassis Dynamometer



REQUIRED RETROFIT SYSTEMS

1998: Baseline

NON-TRAP

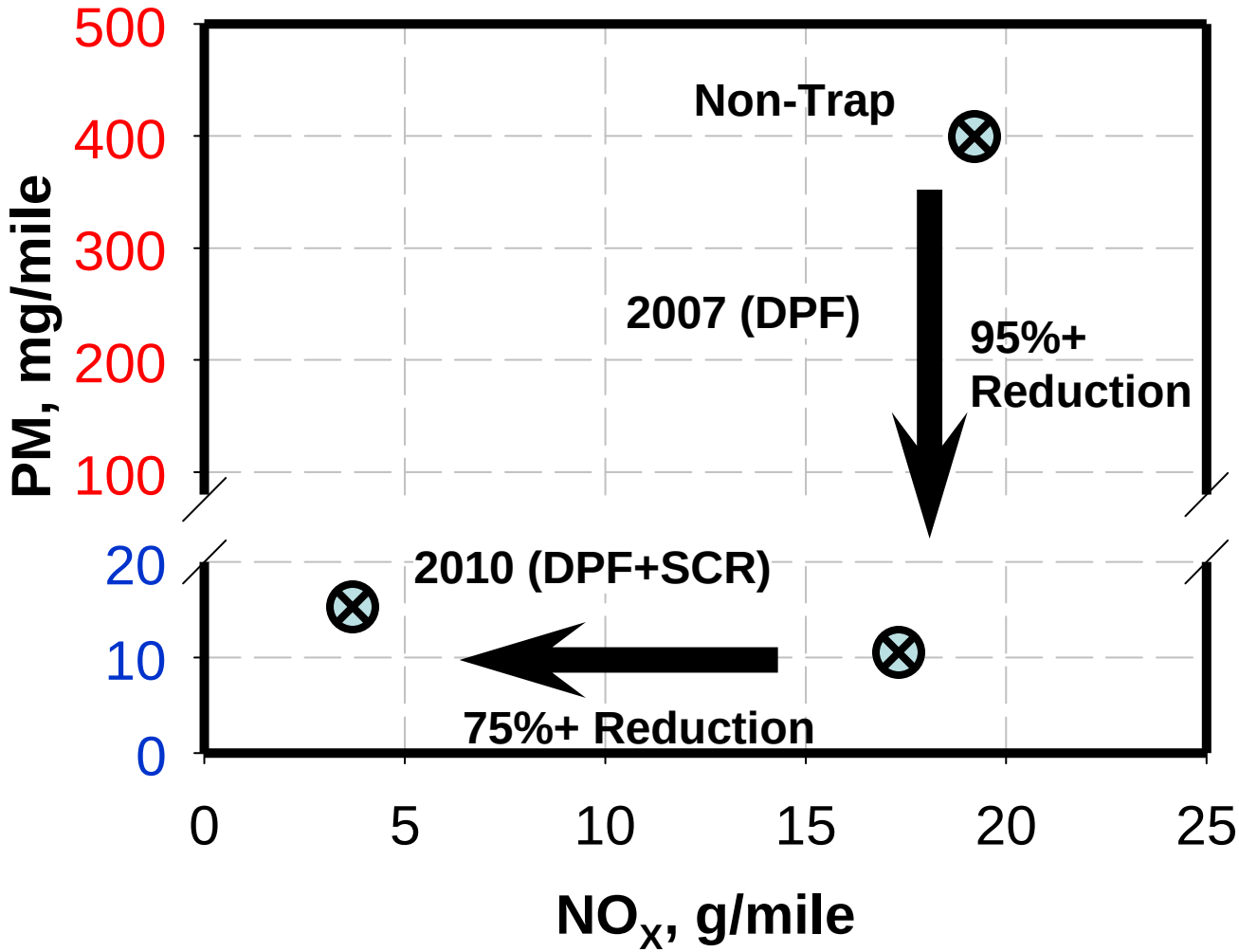
2007: PM Standard

DIESEL PARTICULATE FITLER (DPF)

2010: PM and NO_X Standard

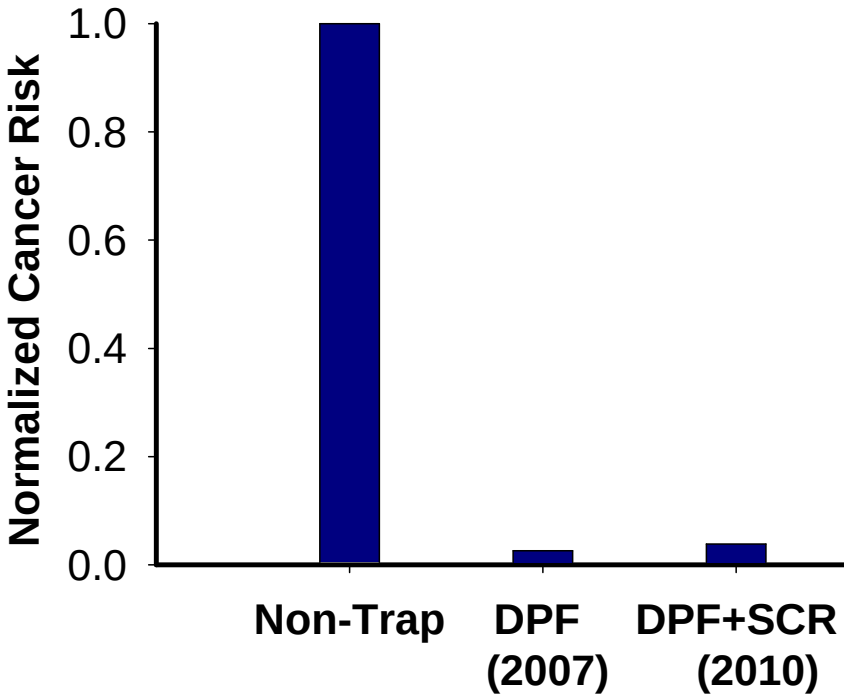
DIESEL PARTICULATE FITLER + SELECTIVE CATALYTIC REDUCTION (DPF +SCR)

SIGNIFICANT REDUCTION OF TOXIC PM and NO_X EMISSIONS BY TRAPS

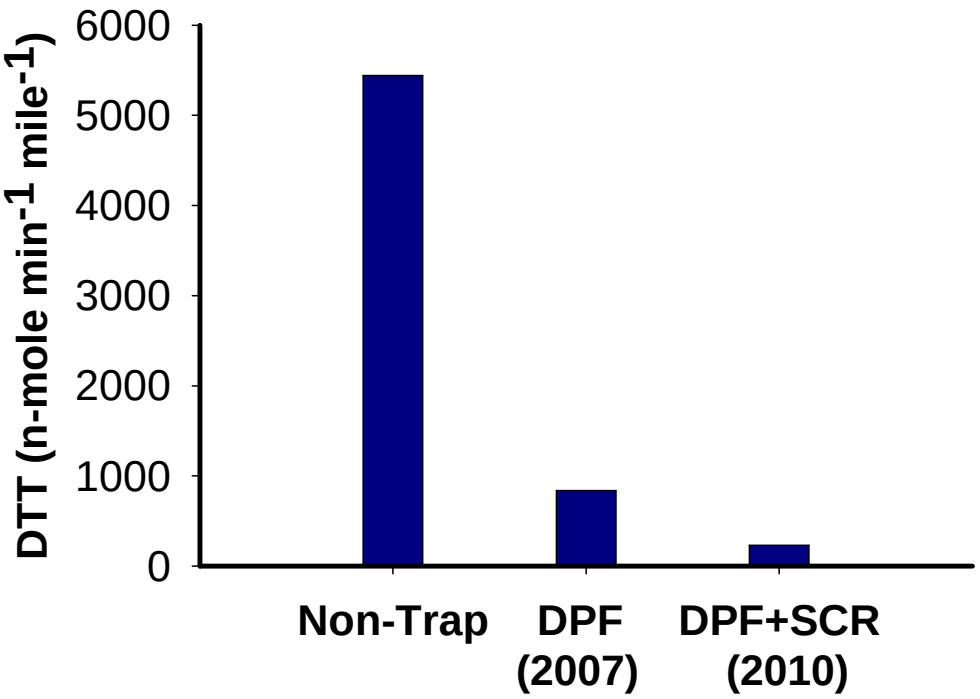


CANCER RISK & OXIDATIVE STRESS POTENTIAL

RELATIVE CANCER RISK

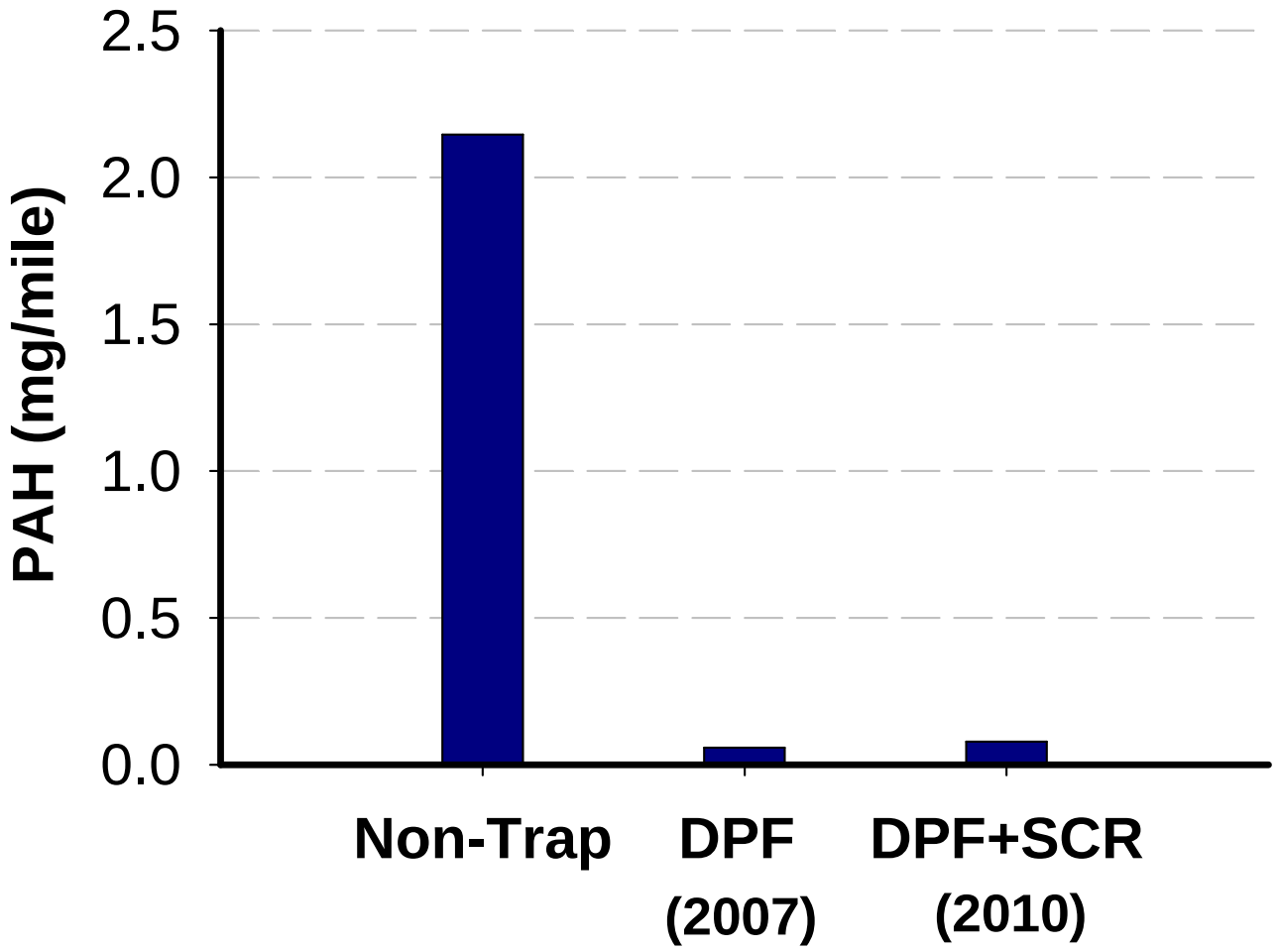


OXIDATIVE STRESS POTENTIAL*



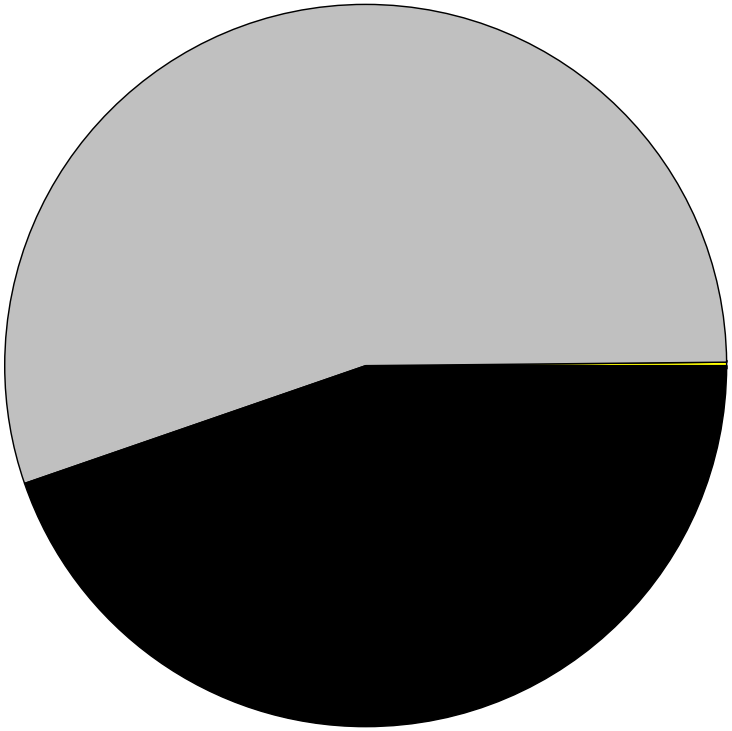
* This indicator of toxicity is reduced by retrofits. This indicator is not definitive. Other toxicity related assays are being conducted.

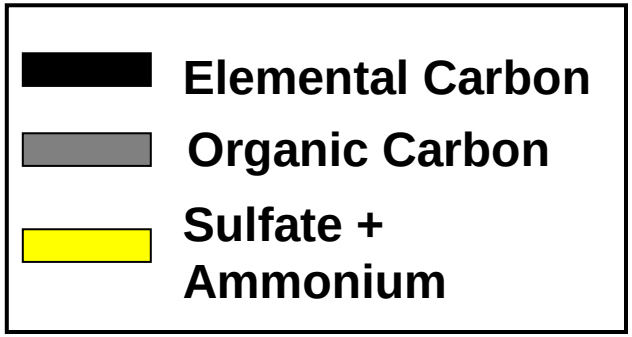
99%+ REDUCTION OF PARTICLE AND VAPOR-PHASE PAH



CHEMICAL COMPOSITION CHANGES

Ammonium sulfate dominates composition of particle emissions from catalyzed retrofits



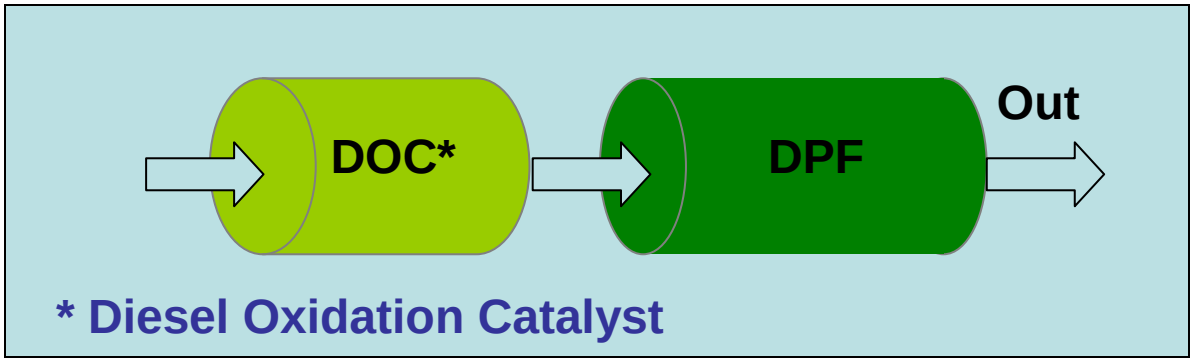


Non-Trap
PM = 400 ± 73 mg/mile

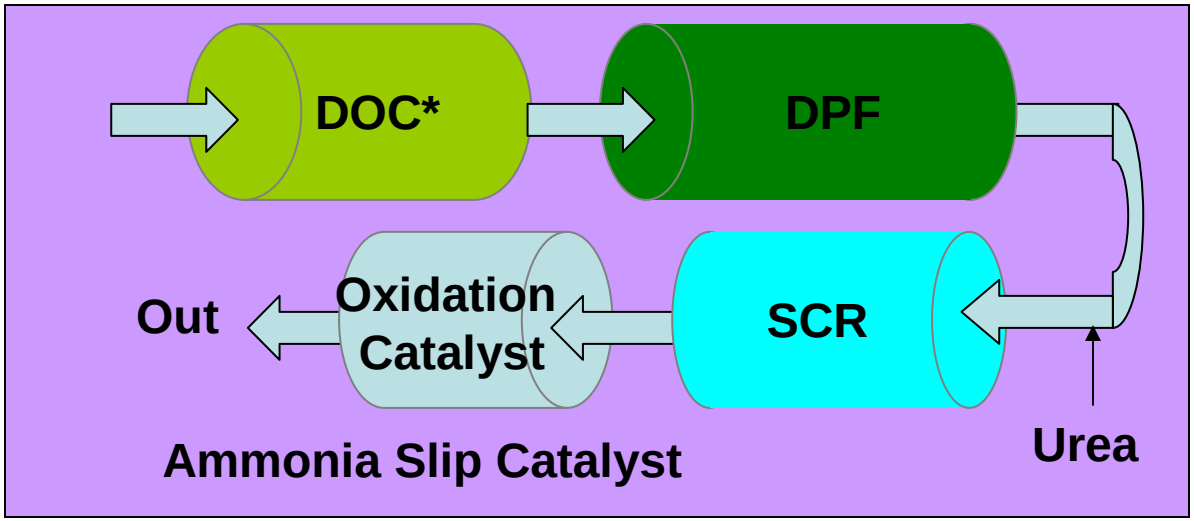
DPF +SCR
PM = 15 ± 11 mg/mile

RETROFIT COMPONENTS

2007: DIESEL PARTICULATE FITLER (DPF)



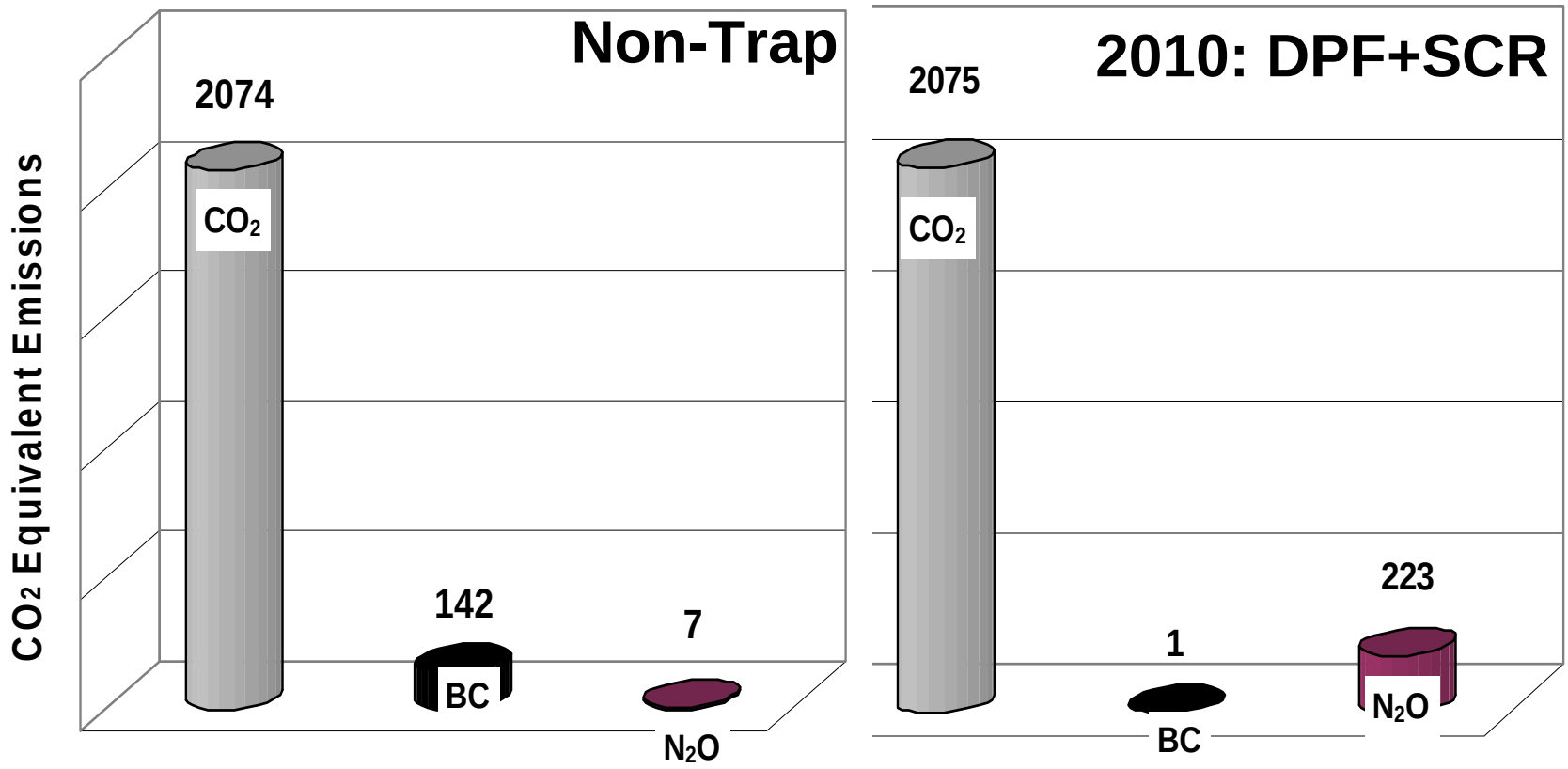
2010: DIESEL PARTICULATE FITLER (DPF) + SELECTIVE CATALYTIC REDUCTION (SCR)



RETROFITS AND ULTRAFINE PARTICLES

- **Engine-out Ultrafines (Soot)**
  - Particle numbers reduced by more than a factor of one thousand by trap
  - Particle number emissions often below background
- **Trap-generated Ultrafines (Volatiles)**
  - Formation of new ultrafine particles by trap under some conditions
  - Then, under those conditions, particle counts comparable to non-trap values
  - But composition and nature of these new particles appears less threatening than soot

NET GREENHOUSE GAS IMPACT IS MINOR



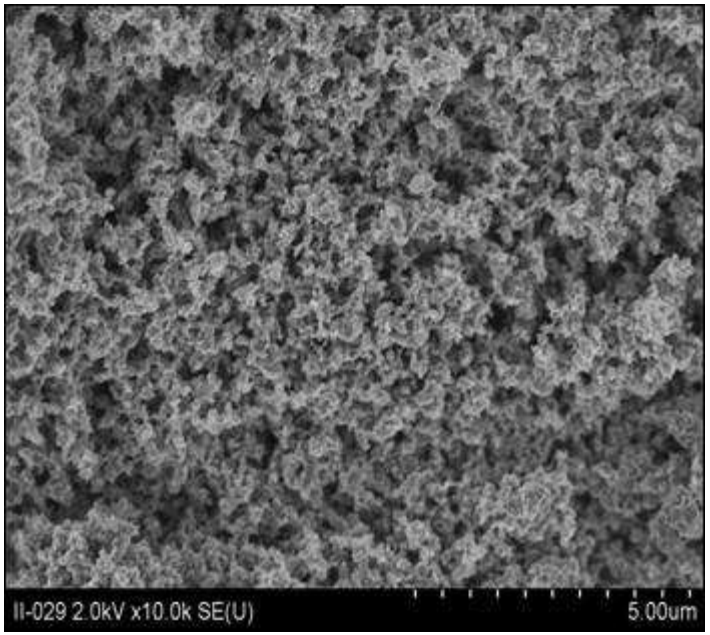
- **Black Carbon Reduced By DPF**
- **N_2O Increased by Retrofit SCR (Prototype)**
- **Better Fuel Economy (Reduced CO_2) Anticipated for New OEM Systems**

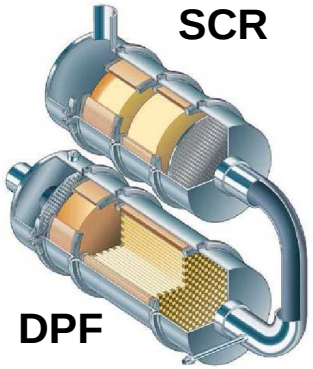
KEY OBSERVATIONS

- **Design Benefit Achieved**
  - Significant reduction of PM and NO_X emissions
  - Corresponding reduction in health risks
- **Remaining PM Appears More Benign**
  - Soot and PAH greatly reduced
  - One indicator of oxidative stress is reduced
- **Greenhouse Gas Potential Benefit**
  - Retrofit is neutral: BC reduced / N_2O increased / CO_2 unchanged
  - OEM potential benefit: BC reduced / N_2O reduced / CO_2 reduced
- **Research Continues on Technical Details**
  - Measurements and impacts of particle number
  - Cellular and chemical assays of oxidative stress potential

SOOT REMOVAL BY TRAP

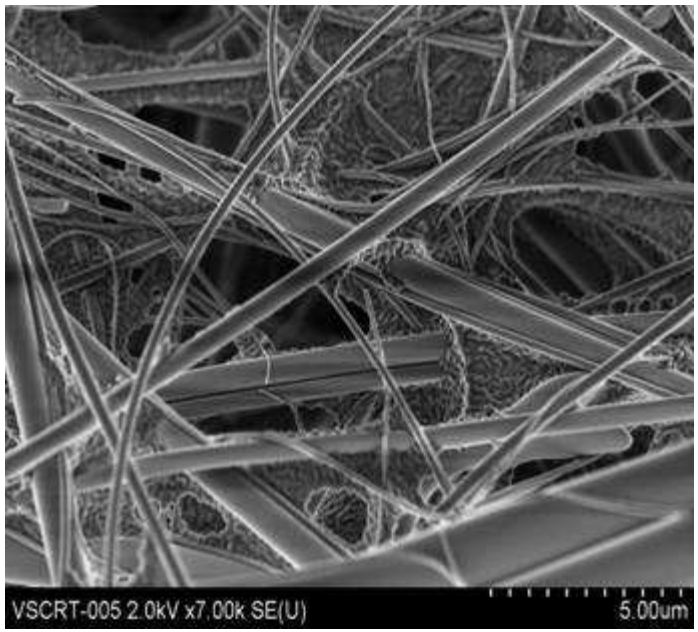
SOOT PATICLES ON BASELINE FILTER SAMPLE





DPF+SCR

ALMOST NO PARTICLES ON 2010 FILTER SAMPLE



*** Filter Sample Micrographs Courtesy of D. Su, Fritz-Haber Institute**